CLAIMS

[1] A repair method of a machine component for repairing a portion to be repaired of an electrically conductive machine component, the repair method of the machine component characterized by comprising:

a removal step of removing a defect generated at the portion to be repaired of the machine component; and

a deposition step of forming a porous deposition after finishing the removal step by employing a molded electrode composed of a molded body molded from a powder of a metal, a mixed powder of a powder of a metal and a powder of a ceramic, or the molded body processed with a heat treatment, and generating a pulsing electric discharge between a removed portion from which the defect in the machine component is removed and the molded electrode in an electrically insulating liquid or gas so that a material of the molded electrode or a reaction substance of the material carries out deposition, diffusion and/or welding at the removed portion of the machine component by energy of the electric discharge.

[2] The repair method of the machine component recited in claim 1, characterized by comprising:

a finish step of carrying out a finish machining to required dimension after finishing the deposition step so as to make a thickness of the deposition to be a predetermined thickness.

[3] The repair method of the machine component recited in claim 2, characterized in that, in the finish step, the finish machining to required dimension so as to make the thickness of the deposition to be the predetermined thickness is carried out with forming a high-density thin film at a surface side of the deposition by employing a hard electrode having exhaustion resistance, generating a pulsing electric discharge between the deposition and the hard electrode in an electrically insulating liquid or gas and melting the surface side of the deposition by means of energy of the electric discharge.

[4] The repair method of the machine component recited in claim 2 or claim 3, characterized by comprising:

a peening step of processing a surface side of the deposition with a peening treatment after finishing the finish step.

[5] The repair method of the machine component recited in any claim from claim 2 to claim 4, characterized by comprising:

a hard thin film step of forming a hard thin film having abrasiveness after finishing the finish step by employing a hard molded electrode composed of a molded body molded from a mixed powder of a powder of a metal and a powder of a ceramic or a powder of an electrically conductive ceramic or the molded body processed with a heat treatment, generating a pulsing electric discharge between the deposition and the hard molded electrode in an electrically insulating liquid or gas so that a material of the hard molded electrode or a reaction substance of the material carries out deposition, diffusion and/or welding the thin film in the deposition by energy of the electric discharge.

[6] The repair method of the machine component recited in any claim from claim 2 to claim 4, characterized by comprising:

a hard thin film step of forming a hard thin film having abrasiveness after finishing the finish step by employing a Si electrode composed of a solid body of Si, a molded body molded from a powder of Si by compression by pressing, or the molded body processed with a heat treatment, generating a pulsing electric discharge between the deposition and the Si electrode in an electrically insulating liquid including alkane hydrocarbon so that a material of the Si electrode or a reaction substance of the material carries out deposition, diffusion and/or welding the thin film in the deposition by energy of the electric discharge.

[7] The repair method of the machine component recited in any claim from claim 2 to claim 6, characterized in that, in the finish step, by employing a hard electrode having exhaustion resistance and generating a pulsing electric discharge between the hard electrode and the portion to be repaired of the machine component

in an electrically insulating liquid or gas, the defect generated at the portion to be repaired of the machine component is removed by energy of the electric discharge.

[8] The repair method of the machine component recited in any claim from claim 1 to claim 7, characterized by comprising:

a thin film step of forming a porous thin film after finishing the removal step by employing the molded electrode and generating a pulsing discharge between the removed portion of the machine component and the molded electrode in an electrically insulating liquid or gas so that a material of the molded electrode or a reaction substance of the material carries out deposition, diffusion and/or welding at the removed portion of the machine component by energy of the electric discharge; and

a thin film modification step of changing the thin film from a porous state into a high-density state after finishing the thin film step and before starting the deposition step by employing a hard electrode having exhaustion resistance and generating a pulsing electric discharge between the thin film and the hard electrode so that the thin film is melted by means of energy of the electric discharge.

[9] The repair method of machine component recited in any claim of claim 3, claim 7 and claim 8, characterized in that the hard electrode is composed of a solid boy of graphite, tungsten alloys or copper alloys.

[10] The repair method of machine component recited in any claim of claim 1 to claim 9, characterized in that a shape of the tip end portion of the molded electrode is slightly larger than a shape of the removed portion of the machine component so that a portion of the molded electrode which sticks out of the removed portion of the machine component in a view from a discharge direction is exhausted when the pulsing electric discharge is generated between the removed portion of the machine component and the molded electrode.

[11] The repair method of machine component recited in any claim from claim 1 to claim 10, characterized in that the machine component is an engine component of a gas turbine engine.

[12] A production method of a restored machine component for production of a restored machine component, the production method of the restored machine component characterized by comprising:

a removal step of removing a defect generated at a portion to be treated of the original machine component; and

a deposition step of forming a porous deposition after finishing the removal step by employing a molded electrode composed of a molded body molded from a powder of a metal, a mixed powder of a powder of a metal and a powder of a ceramic, or the molded body processed with a heat treatment, and generating a pulsing electric discharge between a removed portion from which the defect in the original machine component is removed and the molded electrode in an electrically insulating liquid or gas so that a material of the molded electrode or a reaction substance of the material carries out deposition, diffusion and/or welding at the removed portion of the original machine component by energy of the electric discharge.

[13] The production method of the restored machine component recited in claim 12, characterized by comprising:

a finish step of carrying out a finish machining to required dimension after finishing the deposition step so as to make a thickness of the deposition to be a predetermined thickness.

[14] The production method of the restored machine component recited in claim 13, characterized in that, in the finish step, the finish machining to required dimension so as to make the thickness of the deposition to be the predetermined thickness is carried out with forming a high-density thin film at a surface side of the deposition by employing a hard electrode having exhaustion resistance, generating a pulsing electric discharge between the deposition and the hard electrode in an electrically insulating liquid or gas and melting the surface side of the

deposition by means of energy of the electric discharge.

[15] The production method of the restored machine component recited in claim 13 or claim 14, characterized by comprising:

a peening step of processing a surface side of the deposition with a peening treatment after finishing the finish step.

[16] The production method of the restored machine component recited in any claim from claim 13 to claim 15, characterized by comprising:

a hard thin film step of forming a hard thin film having abrasiveness after finishing the finish step by employing a hard molded electrode composed of a molded body molded from a mixed powder of a powder of a metal and a powder of a ceramic or a powder of an electrically conductive ceramic or the molded body processed with a heat treatment, generating a pulsing electric discharge between the deposition and the hard molded electrode in an electrically insulating liquid or gas so that a material of the hard molded electrode or a reaction substance of the material carries out deposition, diffusion and/or welding the thin film in the deposition by energy of the electric discharge.

[17] The production method of the restored machine component recited in any claim from claim 13 to claim 15, characterized by comprising:

a hard thin film step of forming a hard thin film having abrasiveness after finishing the finish step by employing a Si electrode composed of a solid body of Si, a molded body molded from a powder of Si by compression by pressing, or the molded body processed with a heat treatment, generating a pulsing electric discharge between the deposition and the Si electrode in an electrically insulating liquid including alkane hydrocarbon so that a material of the Si electrode or a reaction substance of the material carries out deposition, diffusion and/or welding the thin film in the deposition by energy of the electric discharge.

[18] The production method of the restored machine component

recited in any claim from claim 12 to claim 17, characterized in that, in the finish step, by employing a hard electrode having exhaustion resistance and generating a pulsing electric discharge between the hard electrode and the portion to be treated of the original machine component in an electrically insulating liquid or gas, the defect generated at the portion to be treated of the original machine component is removed by energy of the electric discharge.

[19] The production method of the restored machine component recited in any claim from claim 12 to claim 18, characterized by comprising:

a thin film step of forming a porous thin film after finishing the removal step by employing the molded electrode and generating a pulsing discharge between the removed portion of the original machine component and the molded electrode in an electrically insulating liquid or gas so that a material of the molded electrode or a reaction substance of the material carries out deposition, diffusion and/or welding at the removed portion of the original machine component by energy of the electric discharge; and

a thin film modification step of changing the thin film from a porous state into a high-density state after finishing the thin film step and before starting the deposition by employing a hard electrode having exhaustion resistance and generating a pulsing electric discharge between the thin film and the hard electrode so that the thin film is melted by means of energy of the electric discharge.

[20] The production method of the restored machine component recited in any claim from claim 12 to claim 19, characterized in that a cross sectional shape of the molded electrode is slightly larger than an external shape of the portion to be treated of the original machine component so that a portion to be treated of the original machine component so that a portion of the molded electrode which sticks out of the portion to be treated of the original machine component in a view from a discharge direction is exhausted when the pulsing electric discharge is generated between the portion

to be treated of the original machine component and the molded electrode.

[21] The production method of the restored machine component recited in any claim from claim 12 to claim 20, characterized in that the original machine component is an original engine component of a gas turbine engine.

[22] A production method of a machine component for production of a machine component provided with an electrically conductive component main body, a porous weld body formed at a portion to be treated of the component main body, the production method of the machine component characterized by comprising:

a main body step of forming from the component main body;

a deposition step of forming a deposition after finishing the removal step by employing a molded electrode composed of a molded body molded from a powder of a metal, a mixed powder of a powder of a metal and a powder of a ceramic, or the molded body processed with a heat treatment, and generating a pulsing electric discharge between a removed portion from which the defect in the machine component is removed and the molded electrode in an electrically insulating liquid or gas so that a material of the molded electrode or a reaction substance of the material carries out deposition, diffusion and/or welding at the removed portion of the machine component by energy of the electric discharge.

[23] The production method of the machine component recited in claim 22, characterized by comprising:

a finish step of carrying out a finish machining to required dimension after finishing the deposition step so as to make a thickness of the deposition to be a predetermined thickness.

[23] The production method of the machine component recited in claim 23, in the finish step, the finish machining to required dimension so as to make the thickness of the deposition to be the predetermined thickness is carried out with forming a high-density thin film at a surface side of the deposition by employing a hard

electrode having exhaustion resistance, generating a pulsing electric discharge between the deposition and the hard electrode in an electrically insulating liquid or gas and melting the surface side of the deposition by means of energy of the electric discharge.

[25] The production method of the machine component recited in claim 23 or claim 24, characterized by comprising:

a peening step of processing a surface side of the deposition with a peening treatment after finishing the finish step.

[26] The production method of the machine component recited in any claim from claim 22 to claim 25, characterized in that, in the component step, the step is forming from a major part of the component main body by forging or casing and forming from a remaining part of the component main body by machining.

[27] The production method of the machine component recited in any claim from claim 23 to claim 26, characterized by comprising:

a hard thin film step of forming a hard thin film having abrasiveness after finishing the finish step by employing a hard molded electrode composed of a molded body molded from a mixed powder of a powder of a metal and a powder of a ceramic or a powder of an electrically conductive ceramic or the molded body subject to a heat treatment, generating a pulsing electric discharge between the deposition and the hard molded electrode in an electrically insulating liquid or gas so that a material of the hard molded electrode or a reaction substance of the material carries out deposition, diffusion and/or welding the thin film in the deposition by energy of the electric discharge.

[28] The production method of the machine component recited in any claim from claim 23 to claim 26, characterized by comprising:

a hard thin film step of forming a hard thin film having abrasiveness after finishing the finish step by employing a Si electrode composed of a solid body of Si, a molded body molded from a powder of Si by compression by pressing, or the molded body processed with a heat treatment, generating a pulsing electric

discharge between the deposition and the Si electrode in an electrically insulating liquid including alkane hydrocarbon so that a material of the Si electrode or a reaction substance of the material carries out deposition, diffusion and/or welding the thin film in the deposition by energy of the electric discharge.

[29] The production method of the machine component recited in any claim from claim 22 to claim 28, characterized by comprising:

a thin film step of forming a porous thin film after finishing the main body formation step and before starting the deposition step by employing the molded electrode and generating a pulsing discharge between the portion to be treated of the component main body and the molded electrode in an electrically insulating liquid or gas so that a material of the molded electrode or a reaction substance of the material carries out deposition, diffusion and/or welding at the portion to be treated of the component main body by energy of the electric discharge; and

a thin film modification step of changing the thin film from a porous state into a high-density state after finishing the thin film step and before starting the deposition step by employing a hard electrode having exhaustion resistance and generating a pulsing electric discharge between the thin film and the hard electrode so that the thin film is melted by means of energy of the electric discharge.

[30] The production method of the machine component recited in any claim from claim 22 to claim 29, characterized in that a shape of a tip end portion of the molded electrode is slightly larger than a shape of the portion to be treated of the component main body so that a portion of the molded electrode which sticks out of the portion to be treated of the component main body in a view from a discharge direction is exhausted when the pulsing electric discharge is generated between the portion to be treated of the component main body and the molded electrode.

[31] The production method of the machine component recited in any claim from claim 22 to claim 30, characterized in that the

machine component is an engine component of a gas turbine engine.

[32] A machine component characterized by being produced by the production method of the machine component recited in any claim from claim 22 to claim 30.

[33] A machine component characterized by being produced by the production method of the machine component recited in claim 31.

[34] A gas turbine engine characterized by comprising the machine component recited in claim 34.

[35] A repair method of a machine component for repairing a portion to be repaired of an electrically conductive machine component, the repair method of the machine component characterized by comprising:

a defect removal step of removing a defect generated at the portion to be repaired of the machine component by employing a hard electrode having exhaustion resistance and generating a pulsing electric discharge between the hard electrode and the portion to be repaired of the machine component in an electrically insulating liquid or gas; and

a deposition formation step of forming a deposition after finishing the defect removal step by employing a molded electrode composed of a molded body molded from a powder of a metal, a mixed powder of a powder of a metal and a powder of a ceramic, or the molded body processed with a heat treatment, and generating a pulsing electric discharge between a removed portion from which the defect in the machine component is removed and the molded electrode in an electrically insulating liquid or gas so that a material of the molded electrode or a reaction substance of the material carries out deposition, diffusion and/or welding at the removed portion of the machine component by energy of the electric discharge.

[36] The repair method of the machine component recited in claim 35, characterized by comprising:

a finish step of carrying out a finish machining to required dimension after finishing the deposition formation step so as to make a thickness of the deposition to be a predetermined thickness by generating a pulsing electric discharge between the deposition and the hard electrode in an electrically insulating liquid or gas and melting the surface side of the deposition by means of energy of the electric discharge.

[37] The repair method of the machine component recited in claim 35 or claim 36, characterized in that the hard electrode is composed of graphite, tungsten alloys or copper alloys.

[38] The repair method of the machine component recited in claim 35 or claim 37, characterized in that the machine component is an engine component of a gas turbine engine.

[39] A production method of a restored machine component for production of a restored machine component form an electrically conductive original machine component, the production method of the restored machine component characterized by comprsing:

a removal step of employing a hard electrode having exhaustion resistance and generating a pulsing electric discharge between the portion to be treated of the original machine component and the hard electrode so that a defect generated at the portion to be treated of the original machine component is removed by means of energy of the electric discharge; and

a deposition step of forming a porous deposition after finishing the removal step by employing a molded electrode composed of a molded body molded from a powder of a metal, a mixed powder of a powder of a metal and a powder of a ceramic, or the molded body processed with a heat treatment, and generating a pulsing electric discharge between a removed portion from which the defect in the original machine component is removed and the molded electrode in an electrically insulating liquid or gas so that a material of the molded electrode or a reaction substance of the material carries out deposition, diffusion and/or welding at the removed portion of the original machine component by energy of

the electric discharge.

[40] The production method of the restored machine component recited in claim 39, characterized by comprising:

a finish step of carrying out a finish machining to required dimension after finishing the deposition step so as to make a thickness of the deposition to be a predetermined thickness by generating a pulsing electric discharge between the deposition and the hard electrode in an electrically insulating liquid or gas and melting the surface side of the deposition by means of energy of the electric discharge.

[41] The production method of the restored machine component recited in claim 39 or claim 40, characterized in that the hard electrode is composed of graphite, tungsten alloys or copper alloys.

[42] The production method of the restored machine component recited in any claim from claim 39 to claim 41, characterized in that the original machine component is an original turbine component of a gas turbine.

[43] A machine component characterized by being produced by the production method of the original machine component recited in any claim of from claim 12 to claim 20 and from claim 39 to claim 41.

[44] An original machine component characterized by being produced by the production method of the original machine component recited in claim 21 or claim 42.

[45] A gas turbine engine characterized by comprising an original machine component recited in claim 44.

[46] An electric spark machine, in the electric spark machine directly employed in working of the repair method of the machine component recited in claim 35, characterized by comprising:

a table;

a jig provided at the table, to which the machine component is set;

a processing head provided above the table and movable in a vertical direction and a horizontal direction relative to the table;

a first holder to support the molded electrode, the first holder being movable integrally with the processing head;

a second holder to support the hard electrode, the second holder being movable integrally with the processing head; and

an electric power source to generate pulsing electric discharges respectively between a portion to be repaired of the machine component and the hard electrode and between the defect removed portion in the machine component and the molded electrode in an electrically insulating liquid or gas.

[47] An electric spark machine, in the electric spark machine directly employed in working of the repair method of the machine component recited in claim 35, characterized by comprising:

a table;

a jig provided at the table, to which the machine component is set;

a processing head provided above the table and movable in a vertical direction and a horizontal direction relative to the table;

a first holder to support the molded electrode, the first holder being attachable and detachable with respect to the processing head;

a second holder to support the hard electrode, the second holder being attachable and detachable with respect to the processing head;

a replacement unit to replace the first holder and the second holder with respect to the processing head; and

an electric power source to generate pulsing electric discharges respectively between a portion to be repaired of the machine component and the hard electrode and between the defect removed portion in the machine component and the molded electrode in an electrically insulating liquid or gas.

[48] A repair method of a turbine component for repairing an abrasion surface in the turbine component applied to a gas turbine engine, the repair method of the turbine component characterized by comprising:

a removal step of removing a defect generated at the abrasion surface in the turbine component; and

a deposition step of forming a deposition having abrasion resistance under a high-temperature environment after finishing the removal step by employing a molded electrode composed of a molded body molded from any one powder or two or more powders of powder of a cobalt alloy containing chromium, mixed powder of powder of a cobalt alloy containing chromium, powder of a ceramic and powder of an alloy, powder of Ti or powder of TiC, or the molded body processed with a heat treatment, and generating a pulsing electric discharge between a removed portion from which the defect in the turbine component is removed and the molded electrode in an electrically insulating liquid or gas so that a material of the molded electrode or a reaction substance of the material carries out deposition, diffusion and/or welding at the removed portion in the turbine component by energy of the electric discharge.

[49] The repair method of the turbine component recited in claim 48, characterized by comprising:

a finish step of carrying out a finish machining to required dimension after finishing the deposition step so as to make a thickness of the deposition to be a predetermined thickness.

[50] The repair method of the turbine component recited in claim 49, characterized in that, in the finish step, the finish machining to required dimension so as to make the thickness of the deposition to be the predetermined thickness is carried out with forming a high-density thin film at a surface side of the deposition by employing a hard electrode having exhaustion resistance, generating a pulsing electric discharge between the deposition and the hard electrode in an electrically insulating liquid or gas and melting the surface side of the deposition by means of

energy of the electric discharge.

[51] The repair method of the turbine component recited in claim 49 or claim 50, characterized by comprising:

a peening step of processing a surface side of the deposition with a peening treatment after finishing the finish step.

[52] The repair method of the turbine component recited in amy claim from claim 48 to claim 51, characterized in that, in the removal step, by employing a hard electrode having exhaustion resistance and generating a pulsing electric discharge between the abrasion surface in the turbine component and the hard electrode in an electrically insulating liquid or gas, the defect generated at the abrasion surface in the turbine component is removed by energy of the electric discharge.

[53] The repair method of the turbine component recited in claim 50 or claim 52, characterized in that the hard electrode is graphite, tungsten alloys or copper alloys.

[54] The repair method of the turbine component recited in amy claim from claim 48 to claim 53, characterized in that the abrasion surface in the turbine component is an abrasion surface in a shroud of a turbine rotor blade.

[55] A production method of a restored turbine component for production of a restored turbine component from an original turbine component, the production method of the restored turbine component characterized by comprising:

a removal step of removing a defect generated at an abrasion surface in the original turbine component; and

a deposition step of forming a deposition having abrasion resistance under a high-temperature environment after finishing the removal step by employing a molded electrode composed of a molded body molded from any one powder or two or more powders of powder of a cobalt alloy containing chromium, mixed powder of powder of a cobalt alloy containing chromium, powder of a ceramic and

powder of an alloy, powder of Ti or powder of TiC, or the molded body processed with a heat treatment, and generating a pulsing electric discharge between a removed portion from which the defect in the original turbine component is removed and the molded electrode in an electrically insulating liquid or gas so that a material of the molded electrode or a reaction substance of the material carries out deposition, diffusion and/or welding at the removed portion in the original turbine component by energy of the electric discharge.

[56] The production method of the restored turbine component recited in claim 55, characterized by comprising:

a finish step of carrying out a finish machining to required dimension after finishing the deposition step so as to make a thickness of the deposition to be a predetermined thickness.

[57] The production method of the restored turbine component recited in claim 56, characterized in that, in the finish step, the finish machining to required dimension so as to make the thickness of the deposition to be the predetermined thickness is carried out with forming a high-density thin film at a surface side of the deposition by employing a hard electrode having exhaustion resistance, generating a pulsing electric discharge between the deposition and the hard electrode in an electrically insulating liquid or gas and melting the surface side of the deposition by means of energy of the electric discharge.

[58] The production method of the restored turbine component recited in claim 56 or claim 57, characterized by comprising:

a peening step of processing a surface side of the deposition with a peening treatment after finishing the finish step.

[59] The production method of the restored turbine component recited in any claim from claim 55 to claim 58, characterized in that, in the removal step, by employing a hard electrode having exhaustion resistance and generating a pulsing electric discharge between the abrasion surface in the original turbine component

and the hard electrode in an electrically insulating liquid or gas, the defect generated at the abrasion surface in the original turbine component is removed by energy of the electric discharge.

[60] The production method of the restored turbine component recited in claim 57 or claim 59, characterized in that the hard electrode is composed of graphite, tungsten alloys or copper alloys.

[61] The production method of the restored turbine component recited in any claim from claim 55 to claim 60, characterized in that the abrasion surface in the original turbine component is an abrasion surface in a shroud of an original turbine rotor blade.

[62] A restored turbine component characterized by being produced by the production method of the restored turbine component recited in any claim from claim 55 to claim 61.

[63] A gas turbine characterized by comprising the restored turbine component recited in claim 62.